Development of a cultural heritage object BIM model

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Abstract. The BIM technology during her creation has been aimed, first of all, at design and construction branch, but its application in the field of studying and operation of architectural heritage can essentially change and transfer this kind of activity to new qualitative level. The question of effective introduction of BIM technologies at the solution of administrative questions of operation and development of monuments of architecture is considered in article. Creation of the information model of the building object of cultural heritage including a full complex of information on an object is offered: historical and archival, legal, technical, administrative, etc. The 3D model of an object of cultural heritage with color marking of elements on degree of wear and a first priority of carrying out repair will become one of components of model. This model will allow to estimate visually technical condition of the building in general and to gain general idea about scales of necessary repair and construction actions that promotes improvement of quality of operation of an object, and also simplifies and accelerates processing of information and in need of a memorial building assessment as subject to investment.

1. Introduction

Sustainable development of the city is provided as due to development of new territories, and preservation and improvement of the existing building. In a separate cluster, it is possible to select memorial buildings of cultural heritage which saving is a present debt in honor of history of the city or the edge. Tasks of monuments protection - preservation and documenting of historically valuable state which remains at historical, art, scientific or town-planning justification. The museum world filled with not used monuments perishes until interests of society are directed only to their protection.

So that to keep monuments, they need to be used. At the same time they aren't lost and don't depreciate, and are a part of structure which has to develop further. The updating connected with historical aspects is that value of a monument which attaches him the special emotional significance corresponding to interests of society.

Compromise has to be reached between preservation, restoration and reconstruction (updating) with possible change of functional purpose, and also between the protected and modern architectural requirements. If earlier protection of cultural and historical heritage came down to protection of separate outstanding objects, then new approaches to definition of a concept of cultural and historical heritage and its protection assume:

• transition from protection of separate objects to protection of the city landscapes including both especially valuable objects of cultural heritage, and subjects to ordinary building, and also natural landscapes, historically developed ways, etc.;

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• transition from protection only of outstanding monuments to protection of the historical building reflecting a way of life of ordinary citizens;

• transition from protection only ancient monuments to protection of monuments of the 20th century;

• active participation of society, and first of all locals, in preservation of cultural heritage and its integration into social and economic life of the city ("vitalization");

• integration of heritage into everyday life of the city and her transformation into the integral and obligatory element.

In the developed countries of the politician in the field of preservation and regeneration of heritage is based on the principles stated above. Moreover, in a number of the countries, first of all in the countries of Europe, regeneration and integration of cultural and historical heritage even more often are considered as driving force of development of the historical cities in general (heritage-led regeneration).

On the one hand the main collision connected with use of broad understanding of the term "object of cultural and historical heritage" is need to dig up resources for contents and restoration of numerous monuments (to keep all objects of heritage at own expense is an impracticable task for any state). And on the other hand – to integrate heritage objects into economic life of the city and to introduce them into economic circulation.

This subject is very urgent for a research presently. Zheravina O. A. [1], Klimov L. A. [2], Borodkin L. I. [3], Uryutova Yu. A. [4] actively work on the questions connected with preservation of cultural heritage. Foreign scientists and researchers also actively publish the works on this subject, for example such as: Christoph Brumann [5], Soraya Boudia, Sébastien Soubiran [6], Mateja Š mid Hribar. David Bole, Primoch Pipan [7], Vera Murgul [16-22].

Galkova O. V. considers that in definition modern representation about cultural heritage the understanding of importance and unalterability of maintenance in quickly developing society of such habitat of the person in which he will keep communication with the nature and objects cultural is fundamental leave marks. And also understanding that the cultural heritage is an important condition of sustainable development, finding of national identity, harmonious development of the personality [8]. But all historical and cultural monuments are also objects of the property right (state or municipal) that causes their involvement in the property relations, and also need of their effective use.

In some cases it leads to the fact that the territory of a monument is perceived by separate economic entities and officials precisely the potential building site, and an object of cultural heritage – as an obstacle for realization courageous town-planning the decision.

As a result it is possible to observe the facts of partial or full demolition of memorial buildings with preservation of only one of facades of the building and a construction on the released place of modern objects (as a rule, from glass and concrete), superstructures of additional floors, extensions large-scale a construction, etc. It inevitably leads to considerable change of historically developed building of the cities. Thus, here we deal with extremely conflict sphere. There is a collision, on the one hand, of public interests in preservation of objects of cultural heritage, and to another – private interests of owners (other owners) in the most profitable use of monuments and their active inclusion in town-planning activity [9].

According to Dzhandzhugazova E. A. realization reconstruction the historical buildings, and then maintenance their ought states is not only considerable expenses, but also serious responsibility as private owners together with the property right will have to incur obligations for safety of the building and its historical appearance. They will have to restore the new property, to support it in a certain state and to provide free access for tourists. All this will allow to keep cultural heritage, rationally using historical monuments of architecture [10].

Zhunich I. I. in the work notes that the fact of existence of cultural heritage generates cultural and informative tourism. Development of this type of tourism is the important direction in life of the state. This is development of regions, cultural interaction of the people, inflow of the financial means going mainly for development of infrastructure, creation of new jobs and active attraction on labor market of youth, support of monuments of material culture, preservation of non-material heritage [11,12]. Travel and tourism became one of the world's largest branches of business. According to forecasts of UNESCO,

by 2020 the number a travel will increase three times worldwide. Now all regions of the Russian Federation are aimed at development of tourist branch. Travel business stimulates other branches, promotes creation of new jobs, safety of tradition and customs, are provided by fullness of regional and federal budgets. Protection of objects of cultural heritage is one of priority tasks of bodies state˘ the authorities of the Russian Federation, territorial subjects of the Russian Federation and local government – the Federal Law "About Objects of Cultural Heritage (Historical and Cultural Monuments) of the People Russian Federations" [13] acts on the territory of Russia now. The Russian Federation is a huge territory on which unique monuments of religion, history and culture are concentrated. It does Russia by the zone favorable for development of such direction as religious tourism. Cathedrals, mosques, the cult museums and the spiritual centers are tourist objects which are in escalating demand, that is religious tourism in a literal sense becomes a part modern the industries of tourism [14].

But fine location of country monuments (ensembles), as a rule, demands large-scale investment in reconstruction, repair and restoration. The assessment of their market value is necessary for involvement of such objects in a market turnover (purchase and sale, insurance, pledge in bank, etc.), however so far, the corresponding technique in Russia isn't approved, though sufficient there is a lot of separate practices.

The main difficulties at an assessment of monuments in the territory of the Russian Federation are considered in the work by Yaskevich E. E. [15]:

- existence of the federal, regional or local status imposing certain easements on the building (separate constructional elements);
- lack of the developed segment of the market of purchase and sale of similar objects;
- high operational costs;
- others.

The problem of qualitative content and operation of objects of cultural heritage, and also efficiency of control from public authorities of destiny of an object can be separately allocated. To supervisory authority to teach a full complex of urgent information on the memorial building, it is necessary to see a pile of technical documentation, the security obligation, to visit an object, to examine and analyse what repair construction works had to be performed and that is executed upon, etc.

At the same time, in Russia, as well as around the world, there is a rapid transition to BIM technologies. Introduction happens mainly in the construction industry, affecting all chain "design – construction – operation – demolition". But simulars and the program tools created for realization of BIM are universal and open new opportunities, including, in the field of studying and operation of architectural heritage. And these practices of BIM can be applied to the existing architecture monuments, as well as to the work with the certain "generalized" information which doesn't have a direct bearing on some concrete objects, and rather relating to the allocated historical periods, geographical areas or styles.

2. Methods

Information model can be considered as an object and means not only for storage of data on a monument, but also to become the serious tool during the research work with this information, and also in educational and educational and communication activity. This model is also closely connected with monitoring of a condition of an object and its possible use (operation). Thus, information model of an architecture monument is not just his virtual copy transferring construction geometry, and but a certain "intellectual container" with the interconnected information on an object. And the volume of this container is almost not limited, contents can constantly be replenished.

Authors haven't revealed the works lighting similar approach to information modeling of objects of cultural heritage. At the same time, the offer stated further is only the beginning of a research on efficiency of introduction of BIM technologies at the solution of administrative questions of operation and development of memorial buildings.

Introduction of the offer on practical application of creation of BIM models of objects of cultural heritage substantially will simplify and will accelerate process of receiving a full information picture about the memorial building. It is possible to apply it starting with the historical information and legal

questions and finishing with data on the planned repair and construction and other actions. The ultimate goal – to improve quality of operation of an object and monitoring of change of his technical condition, and also to increase efficiency of scheduling of repair construction works that in a complex will provide the necessary sufficient level of his safety.

If briefly to formulate value of BIM technologies for monuments history and architecture, then it is:

- new way of fixing of monuments: information can be processed and checked for discrepancy comprehensively;
- new opportunities of monitoring and researches: the model allows to analyze an object in general or in parts;
- possibility of creation of a global information system of monuments of architecture: "internal" information on a monument becomes public for electronic search and the account.

Feature of monuments of cultural heritage is allocation of two main components (technical model) which form a monument of cultural heritage. Those directions of an era are realized in these components in which a concrete object was created. These two components are:

- Skeleton (framework) of the building. All requirements which were imposed to construction of buildings during their creation are considered at his assessment;
- Architectural elements of the building inherent in an era of creation of monuments of cultural heritage.

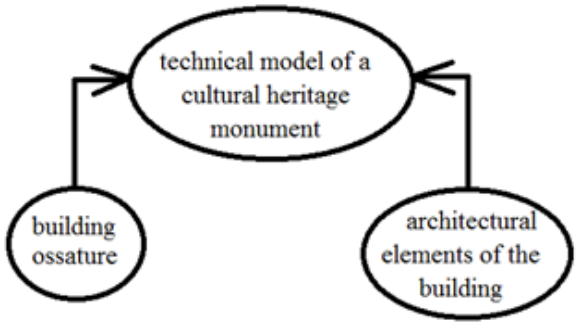

Figure 1. Two components of the building as monument of cultural heritage.

Thus, the model of a monument of architecture has to be built almost element-wise with the detailed description of properties of each element. Moreover, in addition to the main requirements imposed to information models, need of a binding to an object entirely or to his components of historical documents and resources appears for monuments history and architecture. Such additional information can be implemented or through attributes of elements, or through addition in model text or 2D - documents with use of BIM design.

The basic structure of information (BIM) model of the building – an object of cultural heritage is offered to be presented in the form of system of several blocks which maintenance is presented in the figure 2.

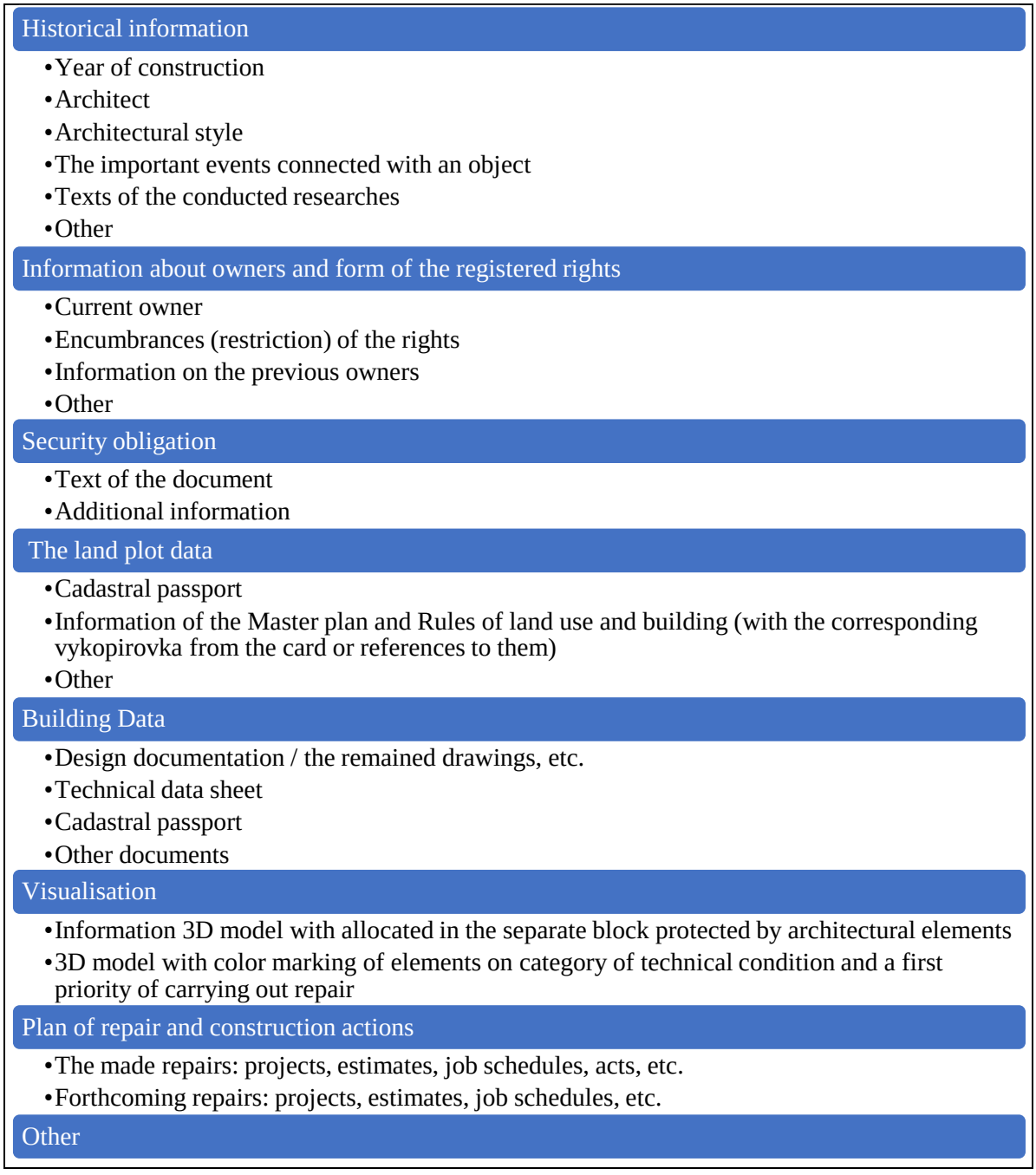

Figure 2. Basic structure of information (BIM) model of the building – an object of cultural heritage.

The block containing a building 3D model with color marking of elements on degree of wear and first priority of carrying out repair is of special interest.

3. Results and Discussion

We will consider the offer on the example of a real object of cultural heritage – F. M. Ambrozhevich's dacha located at the address St. Petersburg, Mr. Pushkin, Moskovskoye Highway, 29, lit. A.



Figure 3. F. M. Ambrozhevich's dacha.

The building 3D model (object of cultural heritage) with color marking of elements on degree of wear and a first priority of carrying out repair has to give a general idea about his technical condition and need of holding repair and construction actions. Color designation of categories of structural elements technical condition of an object can be accepted with necessary extent of specification, for example, four color that will harmonize with GOST 31937-2011 "Buildings and constructions. Rules of inspection and monitoring of technical condition" [23]: green – standard technical condition, yellow – operating, orange – limited and efficient, red – emergency (figure 4).

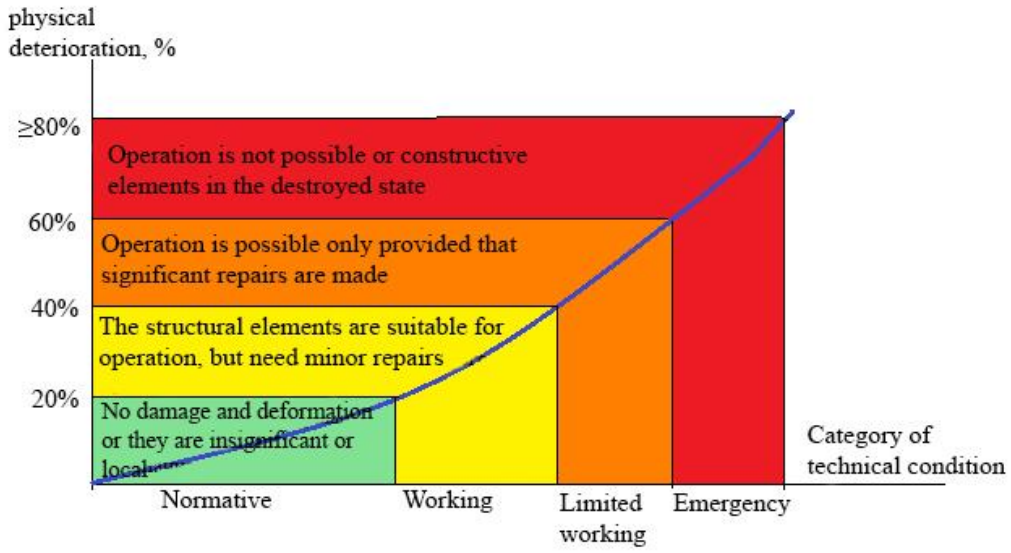

Figure 4. Indicator intervals of technical condition.

The integrated sheet of defects of some structural elements of the considered object has been created according to this classification, elements are chosen by the principle of visibility from the street (for descriptive reasons).

Table. Selective repair list of structural elements.

Building element	Orientation on parts of the world	Description of defect	Category of state
Foundation	Everywhere	The state is limited and efficient. The device of an additional waterproofing is necessary; cleaning of biodamages, strengthening of the base	
Walls	Southeast facade	Walls have partially burned and have collapsed. Some walls have completely burned down.	
	Northwest facade	Operating state. The renovation (paint updating) is necessary.	
	Northeast facade	Operating state. The renovation (paint updating) is necessary.	
	Southwest facade	The state is limited and efficient. Processing of walls antiseptics and fire-retarding agents, painting is necessary.	
Window and doorways	Southeast facade	Emergency condition. In all windows there are no glasses. Replacement of window blocks is necessary.	
	Northwest facade	Operating state.	
	Northeast facade	Emergency condition. In windows partially or completely there are no glasses, frames are damaged. There is an immured window which needs to be restored	
	Southwest facade	Operating state or emergency. Windows which are closer to a northwest facade in operating state; the windows which are closer to a southeast facade without glasses have burned and need replacement	
Balcony	Northeast facade	The state is limited and efficient. Lack of glasses. Sill flashings need replacement.	
Roof	Everywhere	The state is limited and efficient. Updating of a covering of a roof is necessary; partial restoration of the burned-down parts of rafter system.	

The BIM model taking into account the received results is executed in the Autodesk Revit program. This model allows to estimate visually a building condition in general and to gain general idea about scales of necessary repair and construction actions that promotes improvement of quality of operation of an object, and also simplifies and accelerates process of an assessment of a subject to investment (Figures 5-9).

a)  b) 

Figure 5. a) 3D model, view from the North. B) 3D model, view from the West.

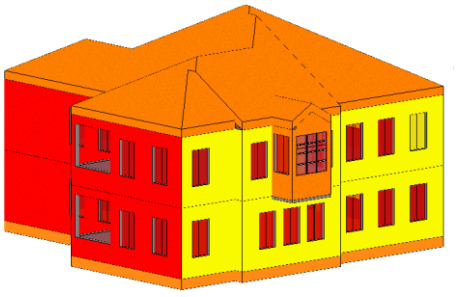

Figure 6. 3D model of building

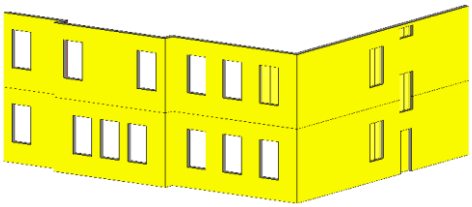

Figure 7. 3D model of building, demonstration of structural elements in operating state.

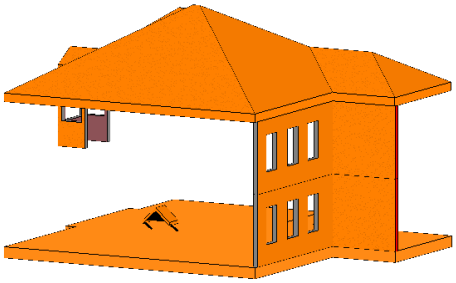

Figure 8. 3D model of building, demonstration of structural elements in limited operating state.

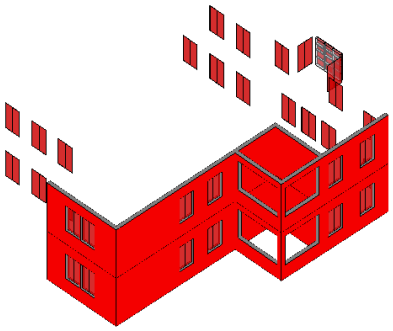

Figure 9. 3D model of building, demonstration of structural elements in a emergency condition.

Also as additional function of visualization it is offered to add pop-up windows with the corresponding photos at guidance of the cursor or allocation of the interesting structural element.

It should be noted that the simplified version of a 3D model is provided in article, in practice it is necessary to create model with the greatest possible extent of specification according to degree of responsibility for safety of an object of cultural heritage.

Also synchronization and addition of an information model of an object of cultural heritage regarding visualization of results of technical survey is possible the practices provided in works [24-27]. It considerably will expand possibilities of data presentation about an object.

Further authors suppose continuation of development of the idea of BIM modeling introduction to the sphere of objects protection of cultural heritage, including, calculation of the practical importance and economic efficiency of offers introduction.

4. Conclusion

It is obvious that the developed standard and legal base which will allow to create programs of sustainable development of objects of history and culture is necessary for uniform model of preservation of heritage and formation of her economic underlying cause in Russia. It will give the chance to put into operation on preservation of heritage natural persons, and also to attract private and commercial investment sector. Changes in system of distribution of powers between branches of executive power, public organizations and research institutes are necessary. Creation of BIM model of a monument will

significantly improve information support of interested persons about all parties and the periods of life of an object. In the long term it will promote improvement of quality of operation of objects of cultural heritage and their safety.

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